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Study of Two Parking Areas in Woburn

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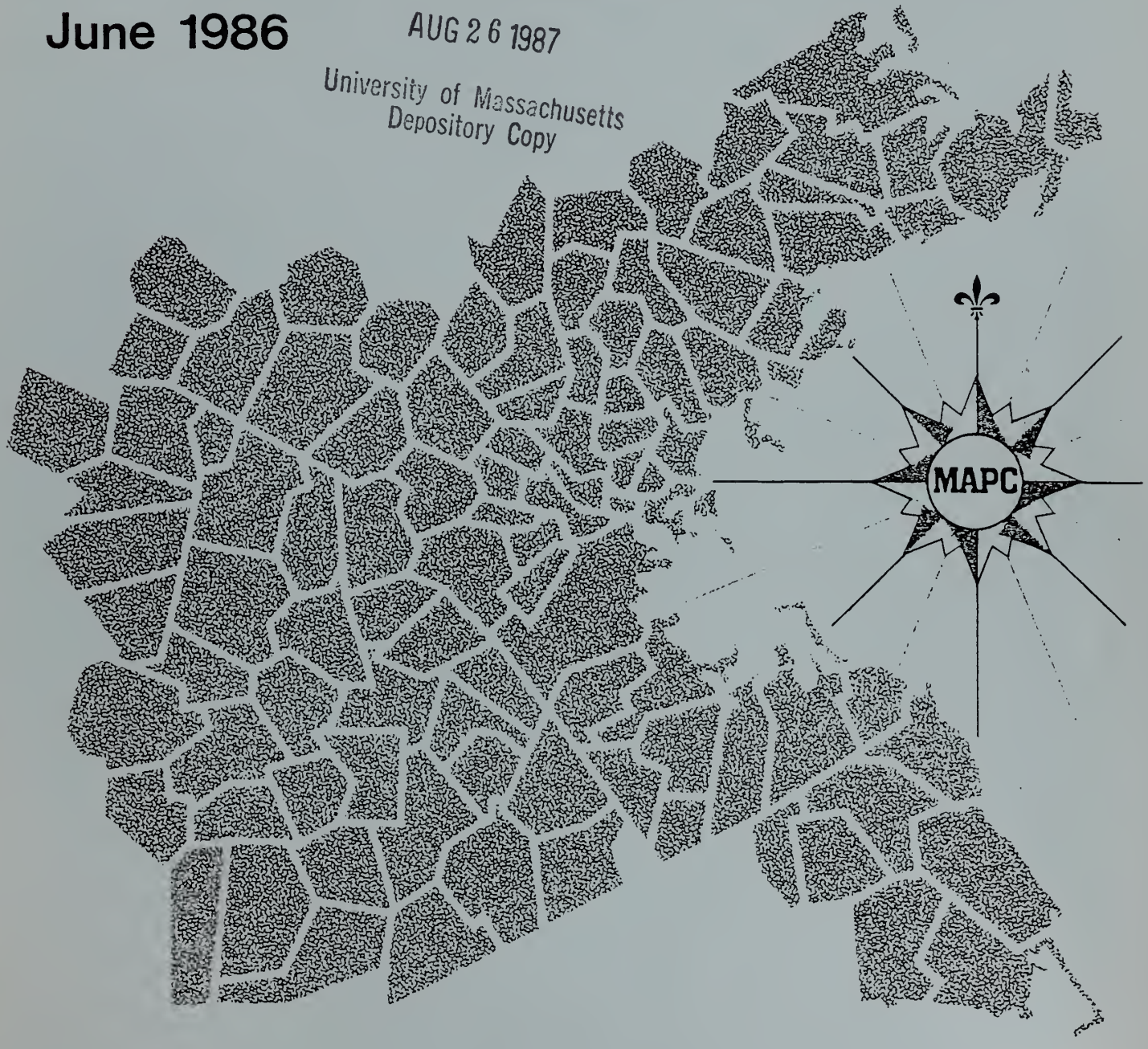

Metropolitan Area Planning Council

110 Tremont Street Boston, Massachusetts 02108

Study of Two Parking Areas in Woburn

August 1986

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I. INTRODUCTION

The City of Woburn has a number of parking facilities in the downtown area, of which two have been identified as needing improvements. The locations of these two lots are shown in Figure 1.

Lot #17, on Main Street across from Hovey Street, currently accommodates 56 cars. The existing parking pattern does not utilize the full area of the lot efficiently; and access to adjacent commercial properties constrains the configuration. There is an erosion problem at two sides of the lot, where there are steep rock and soil banks. There are some meters at this site, but meters throughout the city are in poor repair and there is little, if any, meter enforcement.

Lot #18, adjacent to Walnut Street between Montvale Avenue and Main Street, can accommodate about 300 cars. The configuration in this lot is complex, and in some places undefined. Walnut Street passes through this lot. Parking for several businesses is not entirely separate from public parking. At the time when Woburn requested MAPC's assistance, the situation was also complicated by an incomplete land transaction (since resolved).

At both of these sites, the city wishes to maximize parking capacity in a safe and aesthetically pleasing manner, and to receive revenue from these facilities. In addition, the city would like to consider shifting long term parking to other lots; and maintain through passage on Walnut Street. The City of Woburn requested MAPC's help to clarify the issues related to parking at these sites and provide guidelines for further progress toward the desired physical and operational improvements.

Working together with local officials, MAPC has recommended physical improvements to both lots including resurfacing, landscaping, signing and new systems for collecting parking fees. The recommended improvements are based on the expressed desires of local officials to service businesses, residents, and traffic using both lots. Site specific criteria for the design include:

- maintaining diagonal parking for Walnut Street residents
- reconstructing and widening Walnut Street
- individual meters at Lot #17 (Main Street at Hovey Street)
- time-stamped ticket vending machine at Lot #18 (Walnut Street)

Woburn zoning bylaws require:

- visual screen to surround the lot
- free-draining, dustless surface
- bumpers around perimeter
- lighting directed away from nearby homes

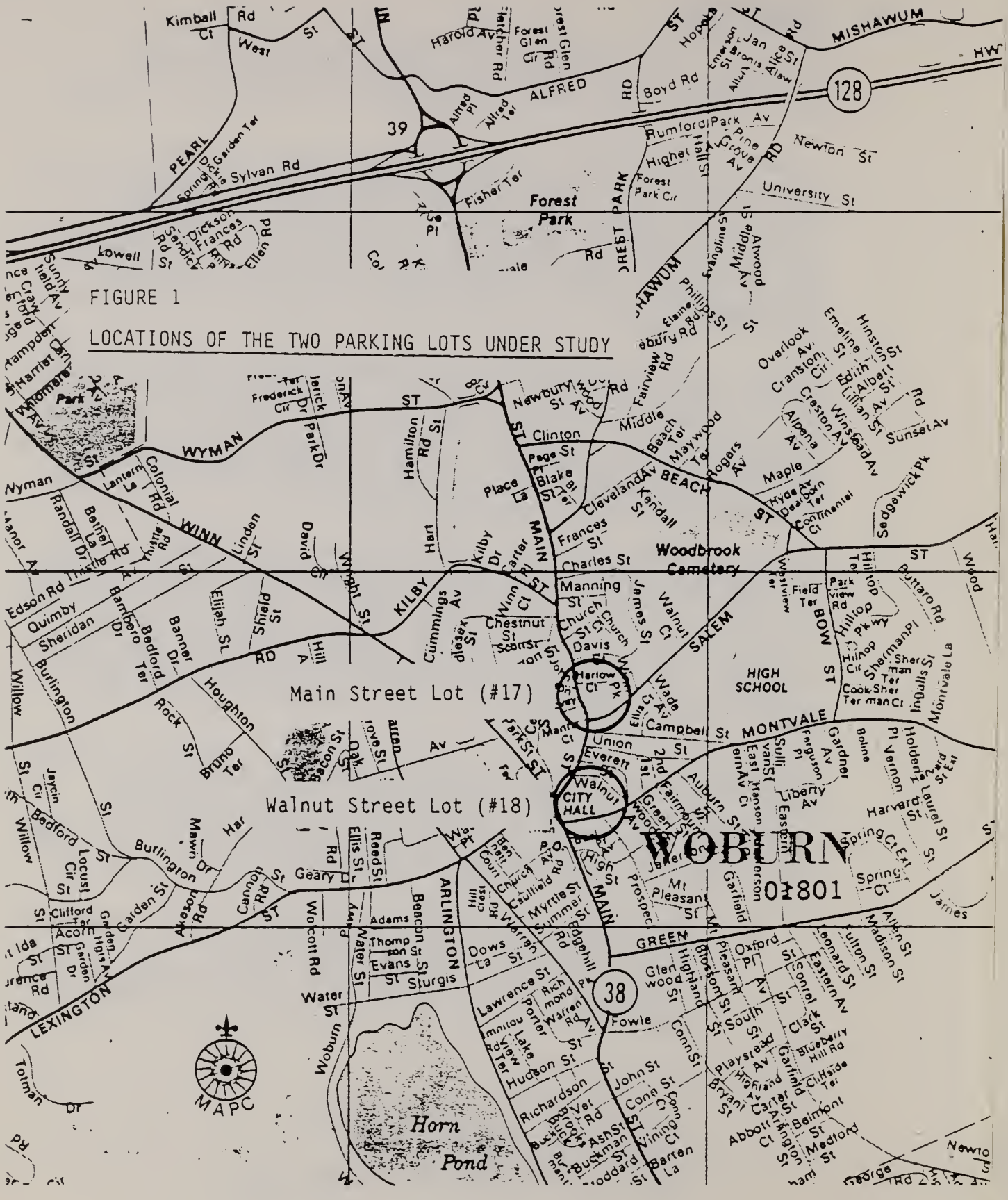


FIGURE 1

LOCATIONS OF THE TWO PARKING LOTS UNDER STUDY

A Handbook by the Institute of Traffic Engineers suggests:

- o separate areas for compact cars in a large lot
- o dimensions of spaces and aisles for alternate parking configurations
- o recommended number of handicapped parking spaces for a given lot size
- o efficient and safe layout for access points and traffic circulation
- o guidelines for landscaping, lighting, and drainage

This report presents these criteria in detail and recommends that the city consider proceeding in three steps. First, estimate the cost of recommended improvements and the possible fee schedules to pay off this investment within a reasonable time. Second, work with businesses, residents, and the City Council to develop a plan which will serve anticipated parking needs and provide needed revenue. And third, work with a consulting engineer to design the new facilities.

II. METHODOLOGY

The study of the two parking areas was divided into four distinct tasks.

Task 1: Property Review

The status of property ownership, access rights, and easements, at the Walnut Street Lot is sufficiently complex that a careful review of city records was necessary. City Solicitor Edward S. Robertson was asked to complete this review and to provide a report to MAPC.

Task 2: Survey of Parking Usage

The city is concerned that the needs for short-term and long-term parking be met and that residences and business adjacent to the public lot continue to enjoy access to their own parking. In order to measure these diverse and possibly conflicting demands, the study included a survey of parking usage. Under MAPC direction, Woburn provided staff to monitor parking at each site for one day (12 hours). The survey data includes, for each vehicle, the arrival time, departure time, and length of stay.

Task 3: Survey of Parking Fee Collection Methods

Given that the city has no method at this point for collecting parking fees, it is appropriate to look at several alternative options, including individual meters, central (multi-slot) meters, and fee collection by an attendant. Capital cost, maintenance cost, and labor were considered, as well as effectiveness, in a literature survey by MAPC staff.

Task 4: Analysis of Alternatives

MAPC staff worked with Woburn officials to analyze several alternatives which satisfy the constraints at these two sites. The alternative which appears to best suit the community's needs is reported in the next chapter.

This report contains the analysis and results of each of these tasks. It includes data, issues, and recommendations indicating the type of layout to be designed. Accepted design standards are referenced in this report and should be used by the city to draw up a final design.

III. ANALYSIS

A. Property Review

The city solicitor's review of property ownership and easements for both lots has indicated that, the City has clear title to both parking lots in their entirety. This conclusion follows the completion of right-of-way taking and land transfer related to a widening of Montvale Ave. There are, however, certain spaces abutting the Walnut St. lot which are owned by neighboring business.

The solicitor also indicates that the City has the exclusive right to control access and egress from Montvale Ave, Main Street and Walnut Street. Walnut Street is a public right-of-way and must remain open to traffic.

B. Parking Usage

Parking usage was monitored at each site for one day (12 continuous hours) to secure data on accumulation and the arrival time and length of stay for each vehicle. The method used to gather this information was a license plate check. As a prerequisite to the survey, each lot was mapped and every available parking space, both public and private, was identified and given a code number. The license plate check was then performed by field observers at hourly intervals recording license numbers for each numbered space.

The survey of parking usage was conducted between 6 AM and 6 PM on Wednesday, February 19, 1986, by seven high school students hired by the Woburn business community and under the supervision of William F. McGowan, Community Development Director. The raw data sheets were then returned to MAPC for analysis. Mr. McGowan also used the license numbers for an additional analysis to determine the users of the lots.

Idiosyncracies inherent in the survey should be noted. First, analysis of the data tends to overestimate parking durations (lengths of stay). For example, using one hour intervals, a vehicle found on only one trip is assumed to be parked for one hour, even if it may have just arrived and leaves soon thereafter. Average stays are overestimated and accumulation underestimated due to the fact that those vehicles that arrive and depart within the hour are missed completely. Furthermore, all parking is also assumed to begin and end within the time limits of the study. If the vehicle is observed on the first or last check of the observer, that time is taken as the arrival or departure time.

With respect to this particular survey, two more factors are relevant. First, due to weather conditions and the uncertain layout of the lots, parking spaces were not clearly defined and there was some "haphazard" parking. Therefore the lots may have seemed closer to full than they actually were. And secondly, in some cases,

survey checks were made on the half-hour. In these instances, the data was included in statistical calculations. However, since the half-hour data was not uniform for the entire study, results have been reported on an hourly basis.

1. Main Street Lot (#17)

The parking usage survey indicates this lot has continuous use throughout the day but is not congested. Figure 2 shows the accumulation of parked vehicles through the day. Although the use is fairly level during the day, the accumulation is greatest at 1 p.m., with 40 of 61 spaces filled. This peak includes lunch-time peaking of arrivals, shown in Figures A1 and A2 of the appendix.

Figure 3 shows the statistical distribution of parked vehicles by length of stay. The largest group stayed at least one hour but less than two hours (35%). All day parking (7 hours or more) included 31% of the observed vehicles. Average parked time was 4.45 hours. Note that 17 vehicles (28 percent of lot capacity) were in the lot at 6:30 a.m. when the survey began.

One more interesting statistic is the turnover rate, in this case equal to 1.3 vehicles per space for 11 1/2 hours. This means that, on the average, each space was used by 1.3 vehicles during the day. This statistic indicates productivity, in terms of the number of auto trips served per parking space.

2. Walnut Street Lot (#18)

The Walnut Street parking Lot (#18) is well used, with 86 percent of the capacity occupied between 10 a.m. and 2 p.m. on the day parking was surveyed. Although there is a substantial amount of all-day parking, almost 60 percent of the observed vehicles stayed less than three hours.

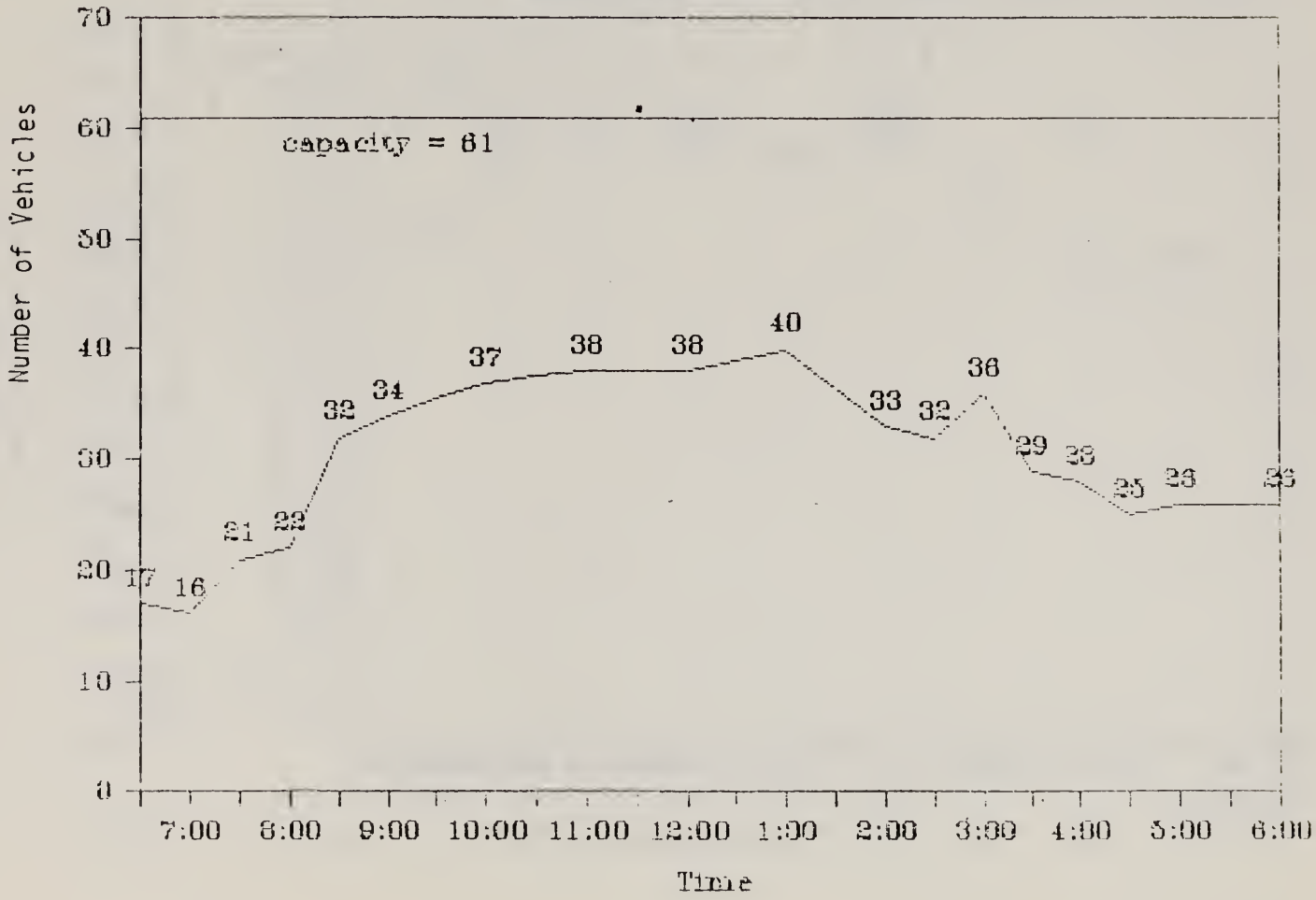
The parking survey took the capacity of the lot to be 250 spaces. An unpaved area adjacent to the lot, which might hold as many as forty vehicles, and a row of diagonal spaces near apartments on Walnut Street were not included in the survey.

At the beginning of the survey, at 6 a.m., 22 vehicles were parked in the lot; and at 6 p.m. 135 vehicles remained (54% of capacity). Sixteen percent of the observed vehicles parked for 7 hours or more. Between 9 a.m. and 5 p.m., the lot was 70 percent full and between 10 a.m. and 2 p.m. it was 86 percent full. Figure 4 tracks the accumulation of parked vehicles through the day.

The turnover of parked vehicles during the survey averaged 2.3 vehicles per space for the 12 hour period. With a reserve capacity margin of at least 10 percent at the peak accumulation (35 spaces) and with 16 percent of vehicles staying for 7 hours or more, one might expect a turnover rate of less than one vehicle per space.

FIGURE 2

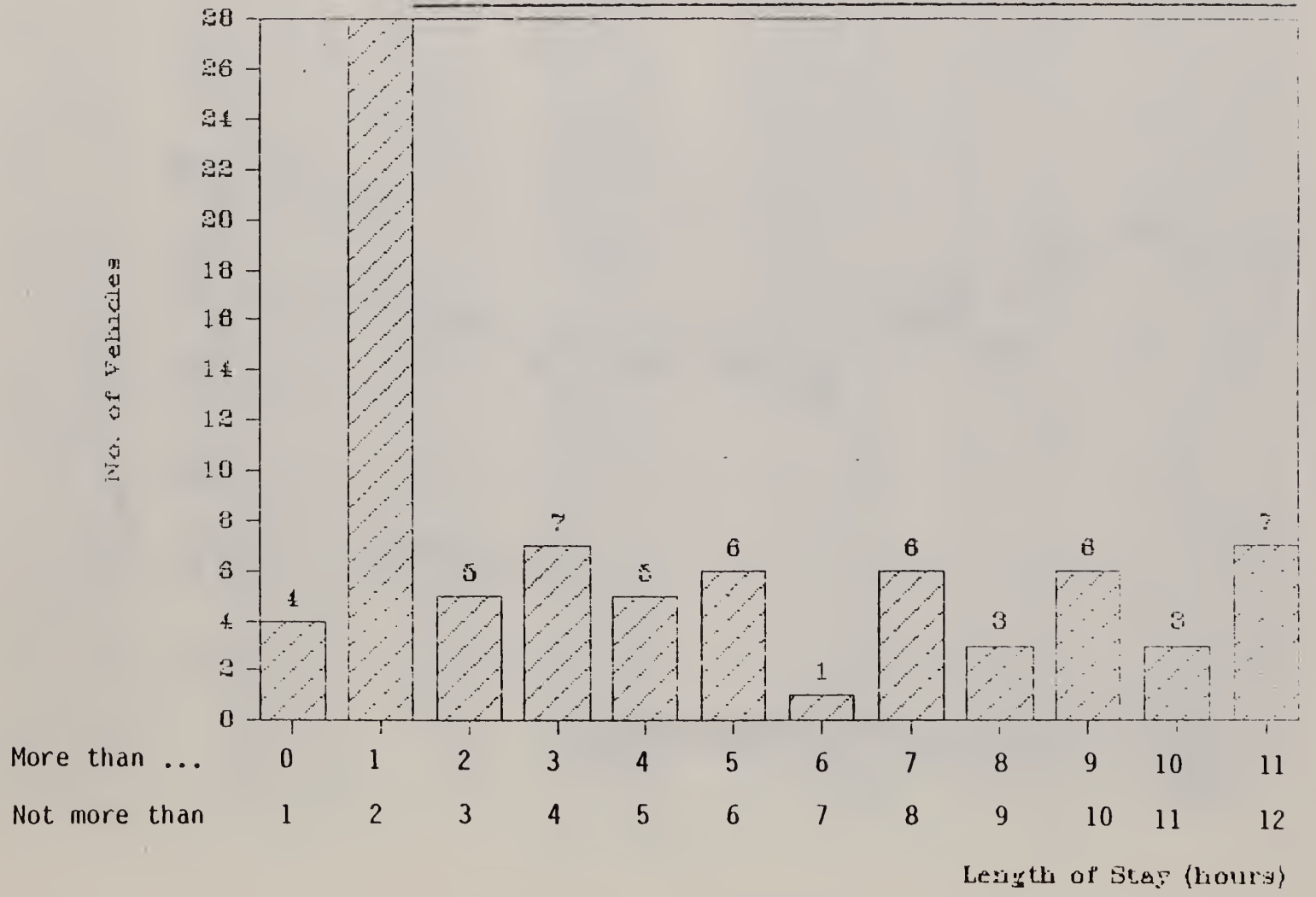
HOURLY ACCUMULATION OF PARKED VEHICLES - LOT # 17



Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

FIGURE 3

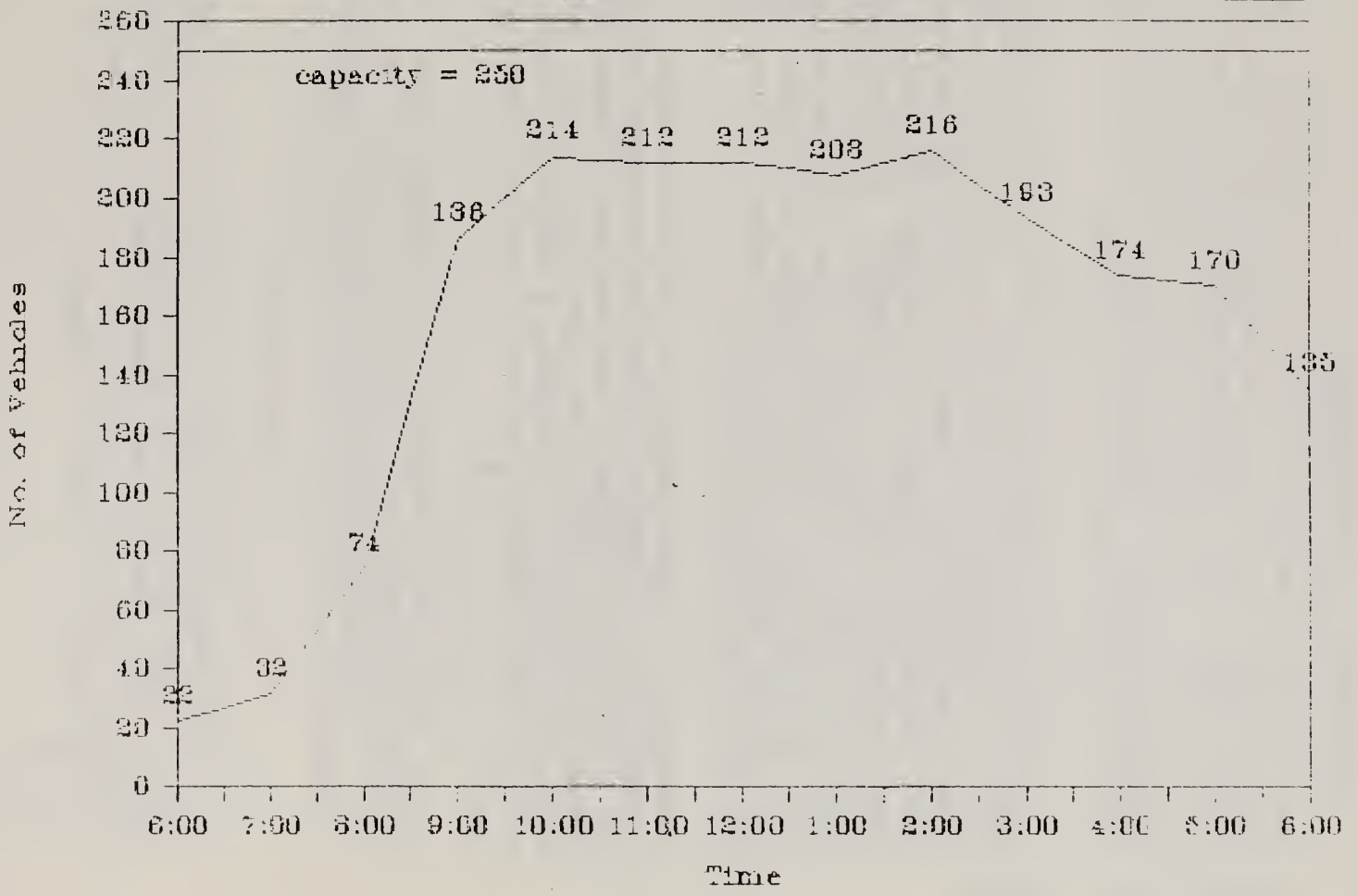
DISTRIBUTION OF PARKED VEHICLES BY LENGTH OF STAY - LOT #17



Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

FIGURE 4

HOURLY ACCUMULATION OF PARKED VEHICLES - LOT #18



Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

However, as figure 5 shows, the majority of those who use this lot stay for much shorter periods - 60 percent stay less than 3 hours. In fact, the most frequently observed length of stay was one hour and the average length of stay was 3.3 hours.

C. Parking Fee Collection Methods

There are several methods of parking fee collection. They vary widely in their requirements for initial capital investment, operating costs, labor intensiveness and levels of equipment sophistication. This section reviews five general types of parking fee collection systems, each in terms of definition, costs (capital, maintenance and labor) and effectiveness. Also discussed is an overview of parking fee pricing structures.

It is appropriate to consider some general points regarding operation of municipal parking lots. A publicly owned parking facility may be operated by the municipality itself or leased to a private operator. Note, however, that although municipal bonds issued for parking purposes are tax-exempt, the leasing of bond-financed facilities to a "non-exempt" operator subjects bond financing to more stringent restrictions. An increasing number of cities have turned to the leasing option with the goal of achieving lower operating costs and more intensive utilization. Another option is for the equipment to be purchased by the municipality and then maintained by service contract.

The concept of "shared parking" has application under certain circumstances. It employs a joint-use arrangement whereby two or more distinguishable types of land use have a common parking area. The success of this type of arrangement depends on a temporal separation of needs. (For example, a bank which is open from 9 a.m. to 3 p.m. could share parking with a restaurant which opens at 5 p.m.).

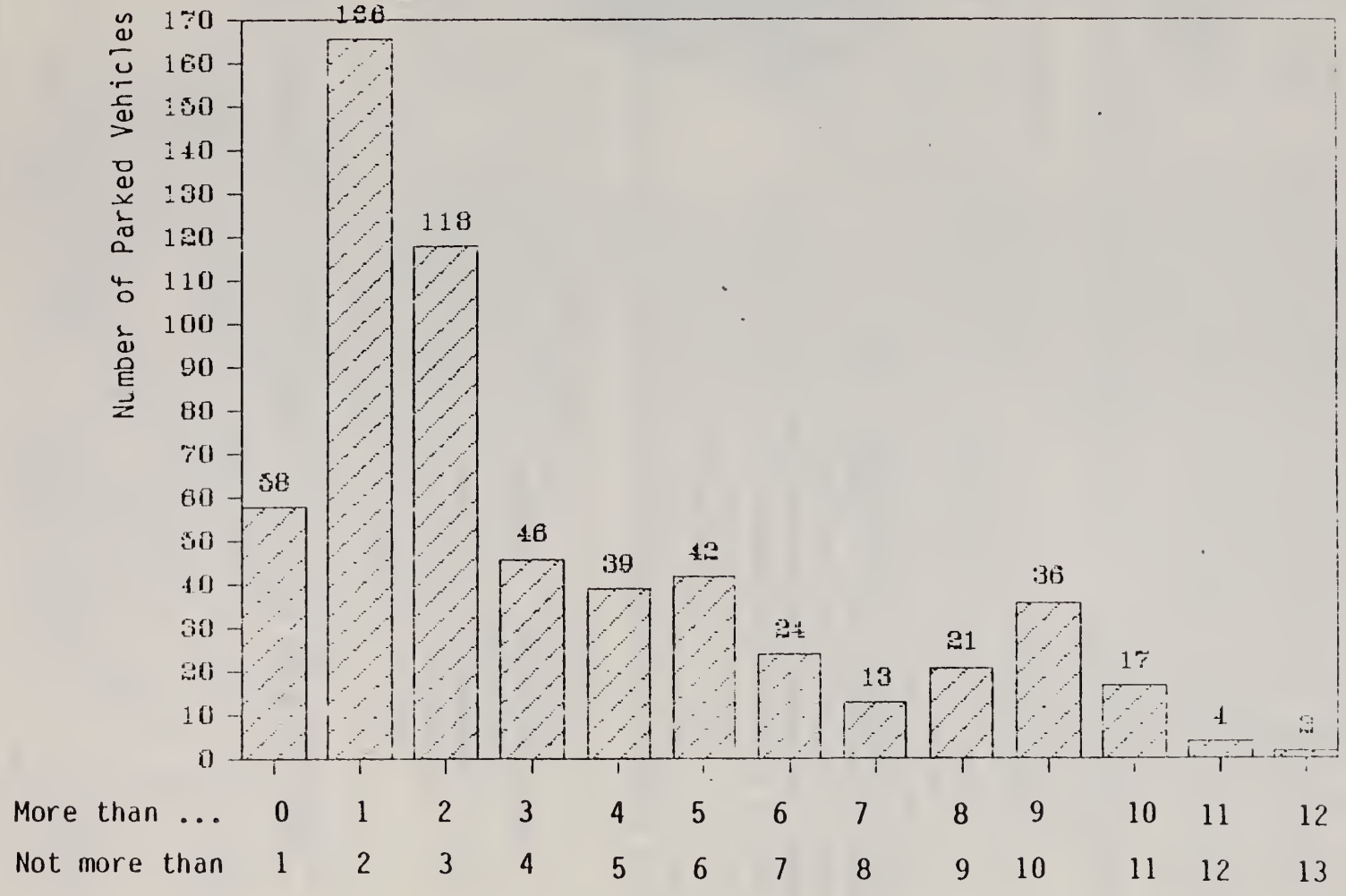
Parking fee collection equipment is a frequent target for vandalism and theft. Equipment may be broken into or the units themselves stolen. Both equipment and monies contained therein are insurable by endorsement on the municipality's General Liability policy.

1. Parking Fees

Parking fees may be structured in a number of ways. The fee may be a flat rate per vehicle, or may be charged by the hour at a flat or variable rate. Fees may vary depending on the walking destination of the user's trip. The fee structure may be related to demand, with the objective of maximizing revenue.

FIGURE 5

DISTRIBUTION OF PARKED VEHICLES BY LENGTH OF STAY - LOT #18



Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

Differential pricing policies are intended to encourage or discourage selected types of parking. Parking may be progressively rated to encourage short-term parking (more expensive per hour as the length of the park increases or even free the first hour). This may be difficult to enforce in that parkers who are located near the lot, for example working in an adjacent store, will move their car to avoid the fee. Alternatively, regressive pricing (charging a cheaper rate for the second hour than for the first, cheaper the third hour than the second, etc.) encourages medium to long term parking, generally by commuters who park to take bus to city. Actions to reduce commuter parking include an added surcharge to the fee for those who park during the morning peak period (6:30-9 a.m.) before most businesses open or a surcharge on long-term parking, above the normal hourly rate. Actions to increase the capacity of a lot serving commuters include carpool/vanpool discounts.

Actions which encourage patronage for stores and businesses in the vicinity of a parking facility include some type of reimbursement to the customer for his parking fee. This can take the form of a ticket validation or or a token program. Some type of receipt is required for proof of parking and validation; in the case of a token program, the act of doing business entitles the patron to a token for his park next time. Types of stamps for validation include adhesive, rubber, and readable magnetic ink. If a system requires that a ticket be left on the dash of a car, a split ticket is needed to take to the establishment for validation.

2. Fee Collection Methods

Five types of fee collection methods are discussed below.

a. A cashier collects money as the customer enters or, more often, exits. Tickets and/or receipts may or may not be dispensed. Security and ease to the customer are advantages of the cashier system. Capital costs to provide a booth range from $600 to $2500+. Operating expenses are high due to wages and overhead, regardless of capacity and/or utilization. Therefore, net cost is low for a large lot with high usage and vice versa.

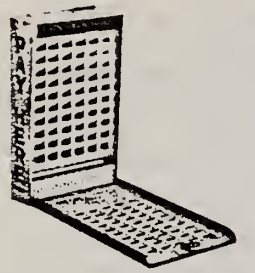
The other four systems discussed below describe "honor parking" systems, referring to the fact that there is not a cashier present to collect fees and therefore collection depends on the customer's honesty. Of course, this system works best in conjunction with an effective violation control program. These unattended parking facilities are automated to some degree. The equipment available on the market ranges from simple, mechanical devices with few or no moving parts to sophisticated, microprocessor-based electronic systems. An overview of the general types of equipment used for honor parking facilities follows. A sample of these general types is pictured in Exhibit 1, taken from a trade journal.

EXHIBIT 1

HONOR PARKING EQUIPMENT GALLERY

There are several types of honor parking devices from which an operator can choose. They range from coin operated meters to magnetic card readers, from non-mechanical slot boxes to the latest microprocessor-based electronic control devices.

On these pages you will find a sampling of the types of equipment available as well as the names and addresses of manufacturers and suppliers of devices associated with Honor Parking.



SLOT BOXES

Slot boxes retain their popularity among Honor Parking operators because of their low cost, ease of operation and rugged construction. They come in a variety of sizes — most typically 35, 60, and 100 slot versions —and accept coins, currency or tokens. Because honor boxes have but two moving parts, the reliability factor is considered a definite asset, as are the improvements in weatherproofing and tamper-resistant locks.

AVAILABLE FROM:

American Parking Equipment, Inc.,
136 Manitoba Street
Toronto, Ontario, Canada M8Y 1E3
(416) 252-7118

Detroit Parking Systems, Inc.
3161 Elliott Avenue
Seattle, WA 98121
(206) 284-6303

Southern Specialties, Inc.
1232 E. 2nd Street
Tulsa, OK 74120
(918) 584-3553

(Photo Courtesy of Detroit Parking Systems, Inc.)

PARKING METERS

Parking meters are found in virtually every city and town in the United States and in many foreign countries. They are familiar sights at municipal, college, hospital and private off-street parking facilities. There are a number of models to choose from including automatic and manual versions with single or multiple slots that accept coins or tokens. Rugged construction and the ability to adjust the meters for varying rates and special needs make the parking meter a mainstay in Honor Parking devices.

AVAILABLE FROM:

Duncan Industries
Division of QONAAR Corp.
751 Pratt Boulevard
Elk Grove Village, IL 60007
(312) 437-0710

GEC Traffic Automation Ltd.
Elstree Way
Borehamwood, Hertfordshire
England WD6 1RX

POM Incorporated
P.O. Box 430
Russellville, AK 72801
(501) 968-2880

(Photo Courtesy of POM Incorporated)

HONOR PARKING SYSTEMS

American Parking, Inc.
410A South Main
Tulsa OK 74103
(918) 587-4141

B.B. Auto Parks, Inc.
621 S. Kenosha Street
Tulsa, OK 74120
(918) 583-4031

Cincinnati Time Recorder
1733 Central Avenue
Cincinnati, OH 45214
(513) 241-5500

Federal APD, Federal Signal Corp., 291 Frontage Road
Hinsdale, IL 60521
(800) 323-4191

Godwin Warren Engineering
3320 Holcomb Bridge Rd.,
#100, Norcross, GA 30092
(404) 449-3446

Park-A-Tron Ltd.
116 Lippan Street
Denver, CO 80223
(303) 534-3564

Parking Systems, Inc.
P O. Box 31
Roselle, IL 60172
(312) 893-3819

Parking Systems & Analysis, Inc., Division of PSA, Inc.
2445 St. Clair Avenue
Cleveland, OH 44114
(216) 621-7764

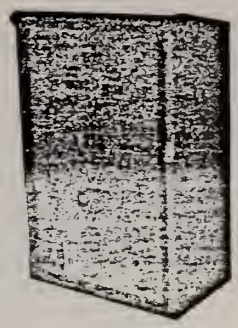
RES/Russco Electronic Systems, 1840 Victory Blvd.
Glendale, CA 91201
(213) 240-2540

Robert's Control Equip. Ltd.
225 Bradwick Drive, Unit 21
Concord, Ontario, Canada
L4K 1B1 (416) 669-6455

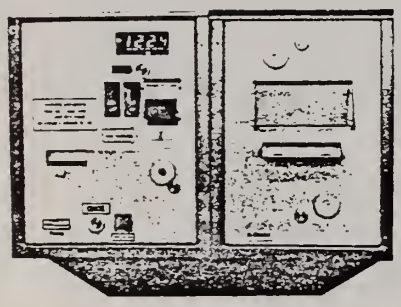
Stanley Parking Systems
32751 Edward Avenue
Madison Heights, MI 48071
(313) 588-1970

Sympark Controls
619 S. New Hampshire Ave.
Los Angeles, CA 90005
(213) 387-0743

The RCE-610 handles up to 500 numbered spaces and is programmable for varying rates. Parking time is prepurchased by the motorist with coins and in return a validation ticket is given as a receipt of purchase. A coin slot closer prevents insertion of money before the space number is typed in. The parking lot controller can make a printout of all spaces in violation, or money collected, or any other pertinent information. The displays are easy to read in direct sunlight and backlighting provides excellent visibility at night. Lots can have multiple entry or exit to eliminate line-ups. Maintenance costs are low.



Contact **Roberts Control Equipment Ltd.**, 225 Bradwick Drive Unit 21, Concord, Ontario, Canada L4K 1B1, (416) 669-6455.



Ticfak machines are electronic multi-space parking control devices with variable rate capability. Ticfak TF4000 issues ticket/receipt to be placed on dashboard of car — attendant patrols lot checking for expired tickets. Ticfak TF5000 operation tied to space numbers — motorist parks, then purchases time for that space —attendant checks for expired spaces at machine with special code.

Standard features: lighted display, rugged construction, heading element, modular components, complex rate capability, "closed" collection system (coin compartment not accessible from mechanism compartment, and money not accessibile to collectors.

Options available: Cash Control, Magnetic Card Reader, Dollar Bill Reader, Gate Operation, Low-ticket Indicator.

Contact: **P.O.M. Incorporated,** P.O Box 430, Russellville, Arkansas 72801, (501) 968-2880

The Park-Ur-Self System provides for the efficient operation of parking areas without the use of full time attendants. Control is achieved through the medium of a highly efficient, mechanical, coin-operated ticket dispenser.

Customers are instructed to deposit coins for a specified period of time. The Model 301 issues a consecutively numbered ticket which is placed "face-up" on the dash. The patroller can readily determine if the number is current for that day or is one that was previously issued and therefore not valid. The Model 302 offers hourly control with the addition of a date and time imprinter.

Consecutively numbered tickets offer precise accounting and revenue control.

The mechanical nature of the equipment offers increased dependability with a reduction in the cost of equipment, installation and service.

For additional information contact:

Park-Ur-Self System, Inc.
8 Commercial Blvd.
Novato, CA 94947 (415) 883-4464

Park-Ur-Self Canada Ltd.
1430 Burrard (Rear)
Vancouver, B.C. V622A3

Park-a-Tron Ltd. has solved the hassle of correct change for self-parking facilities. Park-a-Tron Alpha Model will accept quarters, one or five dollar bills and return the correct change, while retaining the parking fee. Parking fees are adjustable from 25¢ to $24.75 with two built-in pricing structures to accommodate day/night rates. Rates are easily adjusted with a screwdriver in seconds. The Alpha Model has vault-like construction, is weatherproof and is designed so that all functions can be handled by the customer in a drive-up-mode through the car window. Park-a-Tron models have a built-in ticket dispenser with optional day/date imprinters. Park-a-Tron can act as a gate controller for either exit or entry and has an optional card access system.

Also available from Park-a-Tron is a Multi-Coin Converter Kit that can be used to increase the flexibility of some coin operated parking meters by adjusting upward or downward from 25¢ to $3.75. The kit is available in Single ($1.25), Double ($2.50) and Triple ($3.75) configurations.

For further information, contact **Park-A-Tron Ltd.,** 116 Lippan Street, Denver, CO 80223 (303) 534-3564.

Advertisements for other brands are available from the MAPC transportation office or the bimonthly PARKING journal, carried by the State Transportation Library, at 10 Park Plaza in Boston, among other places.

b. The most familiar type of collection equipment is the single slot meter placed by each parking space on a street or in a lot. There are several models to choose from which accept coins or tokens. These meters can be adjusted to varying rates. Vault-like design is resistant to vandals and can be "closed" so that collectors never handle coins. Prices start at $150 per meter. The greatest advantage is that the public is already familiar with how they work. A disadvantage is that no receipt is given for validation by merchants (or other purposes). However, a token program could be substituted in place of receipt validation if local businesses desire.

c. An alternative to placing a meter next to each space, the multiple slot meter is a mechanical device which accepts coins or tokens for many or all of the spaces in the lot. The user receives a ticket to place on the dashboard. The advantage is reduced capital and maintenance costs because of consolidation of equipment (one meter stands in place of several). Also, a split ticket (2 parts) can be issued, with one part used for validation by local businesses and one left in the car for display.

d. Electronic meters utilize micrioprocessors and are similar to an automatic bank teller to operate. They are capable of accepting currency and/or coin and some can give correct change. They also dispense a ticket to be displayed on the dashboard that shows date, time of arrival, amount paid and required departure time, reducing the mental arithmetic required of the customer and/or law enforcer. They compute the fee from time of entry and can calculate charges for multiple rates such as Sundays, holidays, multiple hours and/or free periods. A printed tape shows not only total revenues collected, but length of stay and revenue collected by time. The advantages are their accuracy and flexibility in calculating fees and accepting payment. The disadvantage is their unfamilarity to the public and the high cost of installation and maintenance due to the equipment's degree of sophistication.

e. Slot boxes are simple to operate, although the public is not familiar with them. The customer simply deposits the fee in the numbered slot corresponding to a numbered parking space. Slot boxes may be completely nonmechanical or have only a few moving parts, making them quite reliable. They come in a variety of sizes - most

typically 35, 60, and 100 slot versions and accept coin, currency or tokens. This system relies on spot checks and collection: if the collector finds that a space is full but the corresponding meter slot is empty, then the vehicle is in violation. Prices advertised range from $520 to $675 per box. Advantages include the low cost of installation and maintenance, and simple operation. A disadvantage is that they don't give receipts, but if a local business reimbursement program is desired, tokens can be utilized.

3. Effectiveness

A cashier provides convenience to the customer in many ways and can accommodate decals issued for select purposes or ticket validations by local businesses. A cashier is effective as a deterrent to cheaters and in providing security against theft and vandalism.

The success of honor parking systems is dependent on two major criteria: 1) clear, concise conspicuously posted instructions and 2) enforcement of a violation control procedure.

Unattended facilities require clear and concise signing, located conspicuously. Information posted should include what length parking is available, how much it costs, how to pay and what the consequences are if the customer doesn't pay. If a fine is levied, it should be substantially higher than the costs of parking so that patrons will be discouraged from taking a chance at being caught. Other factors affecting compliance are the searching time required to find a space, walking distance from the car to the central meter or slot box (if used), walking distance to the final destination, occupancy of the facility, and amount of the fee charged.

Methods of violation control include violation tickets, on-site impoundment and tow-away. The need to employ enforcement tactics will be reduced if the policy of issuing a warning or courtesy notice is adopted. The number of violations will be low if customers know vehicles are checked regularly and violators are punished. A uniformed safety officer or attendant should patrol hourly to monitor vehicles and to maintain security.

4. Summary

A community's parking needs are best accommodated by selection of a parking fee collection method that best suits the particular set of circumstances surrounding those needs. Capital and operating costs must be taken into account in making the selection. Who will the patrons be and how may they best be accommodated within the given set of financial constraints?

IV. CRITERIA FOR PARKING LOT IMPROVEMENTS

Many factors will enter into the design of improvements for these two lots. Service to users is the first; service objectives will consider the trade-off between short-term and long-term parking and the special rights and privileges of abutters as well as total capacity. Access to abutting properties and retaining Walnut Street as a public way will also be important considerations. With respect to revenue, both the fee structure and method of collection need to be designed to meet service objectives as well as revenue goals. And, finally, there are a number of physical requirements and amenities to be addressed, including efficient parking layout, handicap spaces, drainage, lighting, landscaping and so forth.

A. Service

Neither of the parking lots studied is currently used to its full capacity, although the Walnut Street Lot had only 35 spaces free at the peak of the day. However, if substantial growth is expected in the area, or if there is a need to relieve an on-street parking shortage, the city may wish to maintain or increase the effective capacity of these lots.

There are a number of options for the Walnut Street Lot. It could be expanded to include the unpaved area toward Montvale Ave. Fees could be charged to encourage a shift in long-term (all-day) parking to other lots such as the underutilized lot behind the library on Abbott Street. And the city has suggested that the MBTA bus stop for an express to Boston could be moved from Montvale Ave, near the Walnut Street lot, to the Abbot Street parking lot. In any case, the city intends to maintain diagonal parking for residents on Walnut Street and access to privately owned spaces abutting the lot.

The Main Street Lot is used to two-thirds of its capacity with about 20 free spaces at the peak of the day. At this point, it appears the lot has adequate capacity to accommodate all users. The city may, however, want to reclaim spaces which are now utilized for access to abutting property or for dumpster storage, apparently without legal right or compensation to the city. Vehicles parked all day constitute almost one-third of the users of this lot and many of the users are employees of nearby businesses. If and when capacity at this lot becomes a problem, those businesses may want to consider other options for employee vehicles.

B. Revenue

Given the cost of improving and maintaining these parking facilities and the need for the city to find revenue to support this essential service, it is recommended that the city implement a system to collect fees for parking at both of these lots. The amount of these fees should of course reflect the costs of providing parking. The fee structure should also be effective in achieving the goals of the

city with respect to parking in the city's center. For instance, at the Walnut Street lot, an hourly fee, with exemptions for short-term parkers visiting nearby businesses, would encourage all-day parkers to move to a free lot, and short and short-term parkers to use this lot (leaving an opportunity to remove on-street parking at congested points).

An effective method for collecting these fees is important. The Main Street Lot is not large enough to support an attendant and probably would be best served by individual meters. However, since the city does not currently maintain such meters elsewhere, it may be advisable to also consider the cost of a central meter box for all 60 spaces.

Fee collection at the Walnut Street Lot relates directly to access. If access and egress are limited, it may be possible to use an attendant. Cost, revenue and safety considerations will also enter into this decision. If the attended facility is not cost-effective, a central meter box will be appropriate with proper enforcement. All of these options are described above.

C. Physical Requirements and Amenities

In addition to capacity and revenue objectives, the physical design must consider access, efficient parking layout, drainage, handicap spaces, lighting, signing and landscaping.

With respect to access, several points have been mentioned previously, as established objectives of the city.

Summarizing those:

- o Walnut Street should remain open as a public way (and perhaps improved).
- o The needs of nearby businesses and homes using the lots should be considered.

Signing is an important part of the parking facility design, especially where there may be a need to change driver habits or direct new users. The Manual of Uniform Traffic Control Devices provides guidelines for specification and installation of such signs; relevant pages from the manual are reproduced in Appendix B.

The final design should also reflect the intent of the city's own standards for parking as set forth in the Revised Zoning Ordinance of 1970. "Parking and Loading Space Specifications" (Section 7.04), in particular, indicates as follows:

1. Parking or loading spaces for more than five vehicles shall be effectively screened on each side which adjoins or faces the side or rear lot line of premises situated in any 'R' District. The screening shall consist of a solid

fence or wall not less than 3 ft. nor more than 6 ft. in height or shrubbery planted not less than 3 ft. apart on center, at least 2 ft. from the lot line, and all maintained in good condition. The screening by this subsection shall be set back from each street the same as if it were a main building wall.

2. Every parking or loading area and access driveways thereto shall be surfaced with a durable and dustless material which shall meet the approval of the Building Inspector and shall be graded and drained so as to dispose of all surface water and accumulation.

3. A substantial bumper of masonry, steel or heavy timer shall be placed near all interior lot lines to protect structures and property abutting a parking or loading area for five vehicles or more.

4. Any fixture used to illuminate any parking or loading area shall be so arranged as to direct the light away from the street and away from adjoining premises used for residential purposes.

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3. Peat, Marwick and Mitchell, Study of Parking Management Tactics Volume II: Overview and Case Study, Federal Highway Administration, Washington, D.C., December 1979.

4. Emery G. Hines, Parking Management, Regional Planning Council, Baltimore, July 1982.

5. Road Research: Evaluation of Urban Parking Systems, Organization for Economic Co-operation and Development, Paris, France, 1981.

6. Federal Highway Administration, Manual on Uniform Traffic Control Devices (1978)

7. Institute of Transportation Engineers, Transportation and Traffic Engineering Handbook (1982)

8. City of Woburn, Revised Zoning Ordinance (1970)

9. Meyers, Catherine E., Parking Fee Collection Methods (Metropolitan Area Planning Council, 1985)

Appendix A

Supplementary Statistics on Parking Usage Survey

Lot #17 (Main Street)

Table A-1 Arrivals, Departures, Parked Vehicles, by hour

Figure A-1 Arrivals, Departures, by hour

Lot #18 (Walnut Street)

Table A-2 Arrivals, Departures, Parked Vehicles, by hour

Figure A-2 Arrivals, Departures, by hour

TABLE A-1

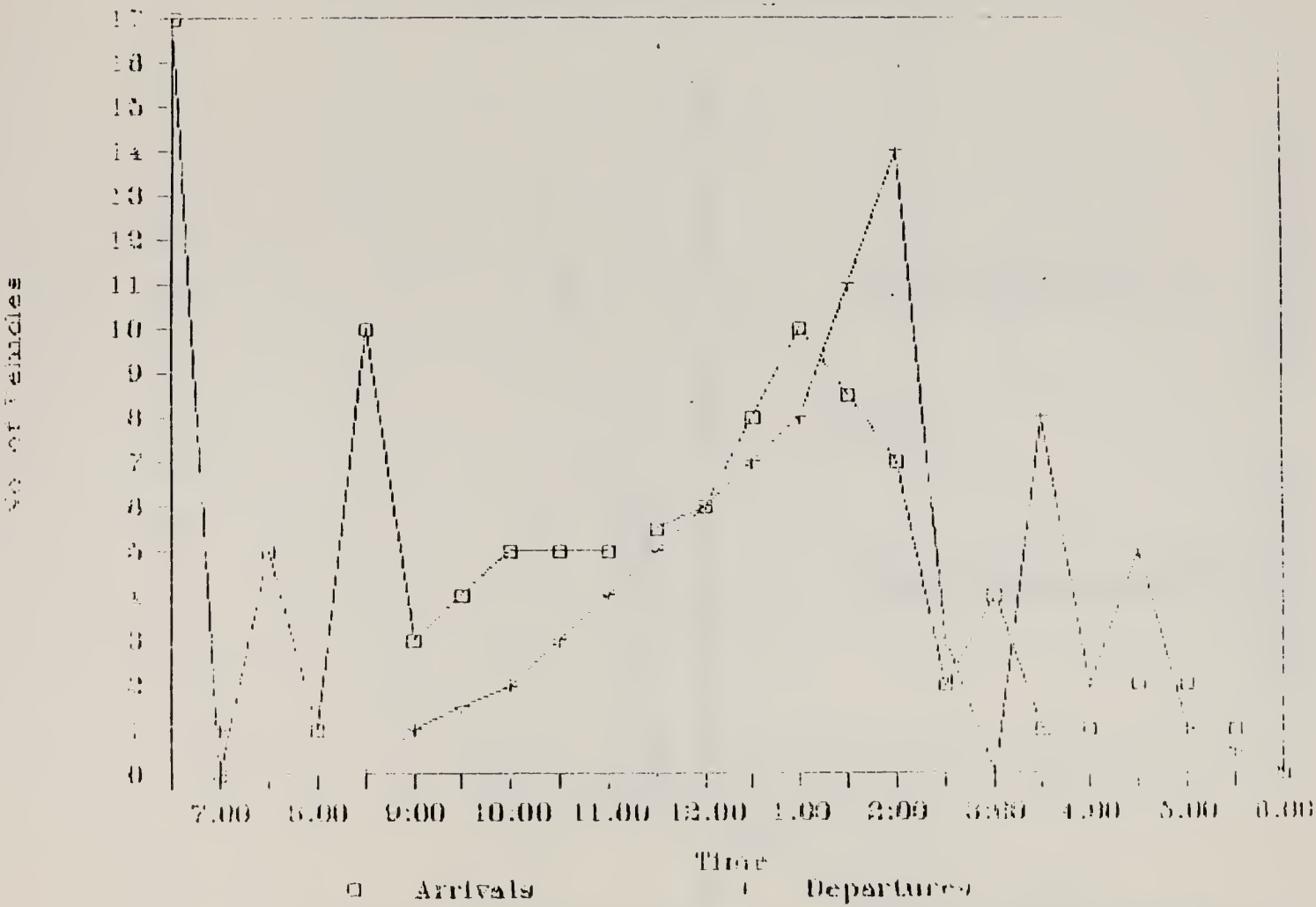
HOURLY ARRIVALS, DEPARTURES, PARKED VEHICLES - LOT #17

Time	No. of Arrivals Since Last Hour	No. of Departures Since Last Hour	No. of Vehicles At This Hour
6:30	17	-	17
7:00	0	1	16
8:00	6	0	22
9:00	13	1	34
10:00	5	2	37
11:00	5	4	38
12:00	6	6	38
1:00	10	8	40
2:00	7	14	33
3:00	6	3	36
4:00	2	10	28
5:00	4	6	26
6:00	0	0	26

Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

FIGURE A-1

HOURLY ARRIVALS, DEPARTURES, PARKED VEHICLES - LOT #17



Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

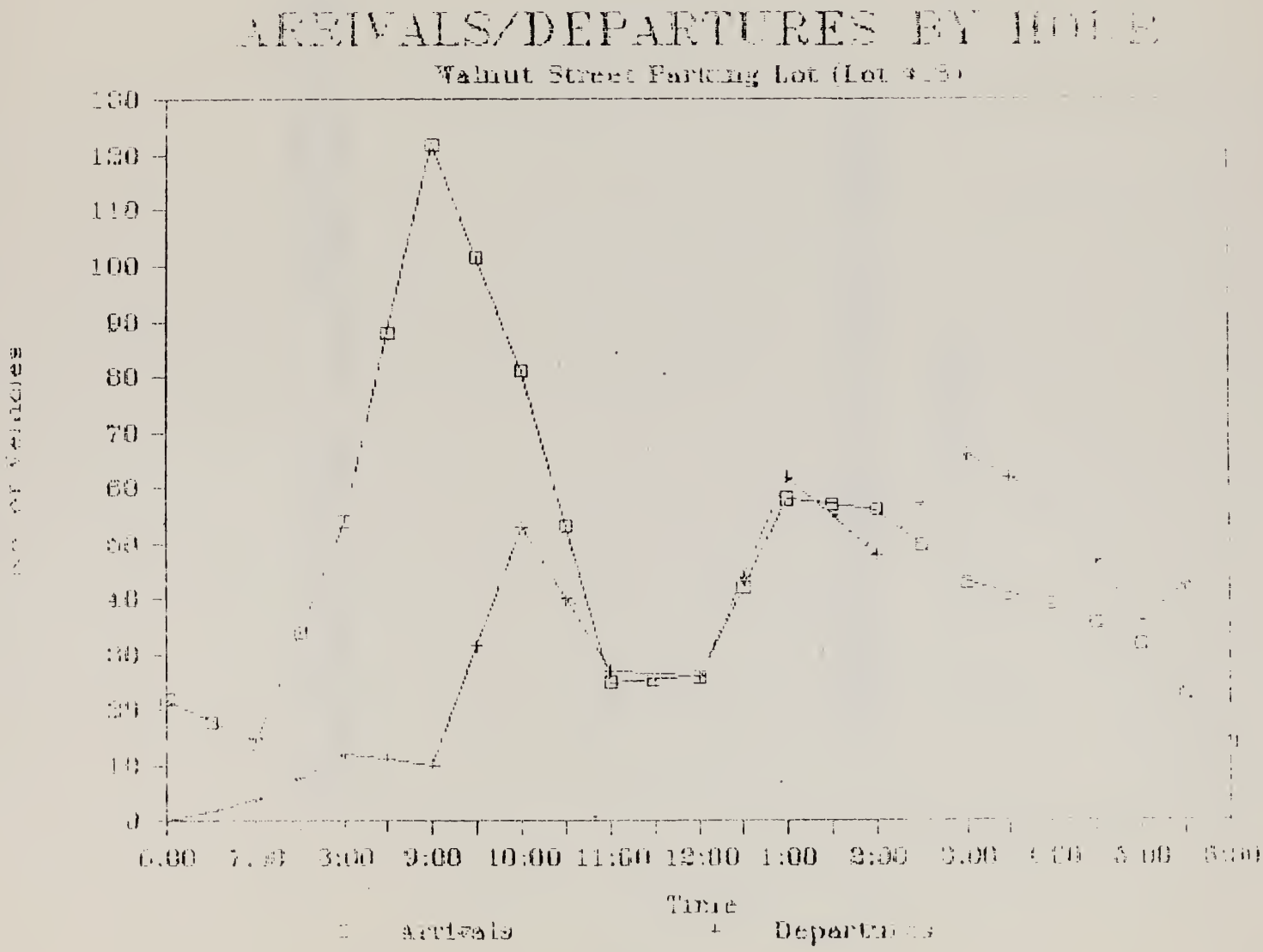
TABLE 1-2

HOURLY ARRIVALS, DEPARTURES, PARKED VEHICLES - LOT #18

Time	No. of Arrivals Since Last Hour	No. of Departures Since Last Hour	No. of Vehicles At This Hour
6:00	22	-	22
7:00	14	4	32
8:00	54	12	74
9:00	122	10	186
10:00	31	53	214
11:00	25	27	212
12:00	26	26	212
1:00	58	62	208
2:00	56	48	216
3:00	43	66	193
4:00	39	58	174
5:00	32	36	170
6:00	14	49	135

Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

FIGURE A-2



Source: License plate survey on February 19, 1986 by Woburn Office of Community Development

Appendix B

Selected Information on Signage for Parking

Source:

Federal Highway Administration, Manual on Uniform Traffic Control Devices (1978)

D4-1
30" x 24"

2D-40 Parking Area Sign (D4-1)

The Parking Area sign may be used where it is desired to show the direction to a nearby parking area for use by the general public. The sign shall be a horizontal rectangle of a standard size of 30 × 24 inches with a smaller size of 18 × 15 inches for minor, low-speed streets. It shall carry the word PARKING, with the letter P five times the height of the remaining letters, and a directional arrow. The legend and border shall be green on a reflectorized white background.

If used, the Parking Area sign should be erected on major thoroughfares at the nearest point of access to the parking facility and where it can help relieve the local streets of traffic seeking a place to park. In general, the sign should not be used more than three or four blocks from the parking area. It shall be mounted in accordance with the general specifications for the erection of signs (secs. 2A-23, 24).

2A-23 Height

Signs erected at the side of the road in rural districts shall be mounted at a height of at least 5 feet, measured from the bottom of the sign to the near edge of the pavement. In business, commercial and residential districts where parking and/or pedestrian movement is likely to occur or where there are other obstructions to view, the clearance to the bottom of the sign shall be at least 7 feet. The height to the bottom of a secondary sign mounted below another sign may be 1 foot less than the appropriate height specified above.

The height requirements for ground installations on expressways vary somewhat from those on conventional streets and highways. Directional signs on expressways shall be erected with a minimum height of 7 feet (from the level of the near edge of the pavement to the bottom of the sign). If, however, a secondary sign is mounted below another sign, the major sign shall be at least 8 feet and the secondary sign at least 5 feet above the level of the pavement edge. All route markers and warning and regulatory signs on expressways shall be at least 6 feet above the level of the pavement edge. However, where signs are placed 30 feet or more from the edge of the nearest traffic lane for increased roadside

safety, the height to the bottom of such signs may be 5 feet above the level of the pavement edge.

A route marking assembly consisting of a route marker with an auxiliary plate (sec. 2D-10) is treated as a single sign for the purposes of this section.

Overhead signs shall provide a vertical clearance of not less than 17 feet over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater than 1 foot in excess of the minimum design clearance of other structures. In special cases it may be necessary to reduce the clearance still further because of substandard dimensions in tunnels and other major structures such as double-deck bridges.

2A-24 Lateral Clearance

Signs should have the maximum practical lateral clearance from the edge of the traveled way for the safety of motorists who may leave the roadway and strike the sign supports. Advantage should be taken of existing guardrail, overcrossing structures and other conditions to minimize the exposure of sign supports to traffic. Otherwise, breakaway or yielding supports should be used.

Normally, signs should not be closer than 6 feet from the edge of the shoulder, or if none, 12 feet from the edge of the traveled way. In urban areas a lesser clearance may be used where necessary. Although 2 feet is recommended as a working urban minimum, a clearance of 1 foot from the curb face is permissible where sidewalk width is limited or where existing poles are close to the curb.

The minimum clearance outside the usable roadway shoulder for expressway signs mounted at the roadside or for overhead sign supports, either to the right or left side of the roadway, shall be 6 feet. This minimum clearance of 6 feet shall also apply outside of an unmountable curb. Where practicable, a sign should not be less than 10 feet from the edge of the nearest traffic lane. Large guide signs especially should be farther removed, preferably 30 feet or more from the nearest traffic lane. Lesser clearances, but not generally less than 6 feet, may be used on connecting roadways or ramps at interchanges.

Where an expressway median is 12 feet or less in width, consideration should be given to spanning both roadways without a center support. Butterfly-type signs and other overhead sign supports should not be erected in gores or other exposed locations. Where overhead sign supports cannot be placed a safe distance away from the line of traffic, or in an otherwise protected site, they should either be so designed as to minimize the impact forces, or otherwise protect motorists adequately by a physical barrier or guardrail of suitable design.

2B-31 Urban Parking and Stopping Signs (R7 Series)

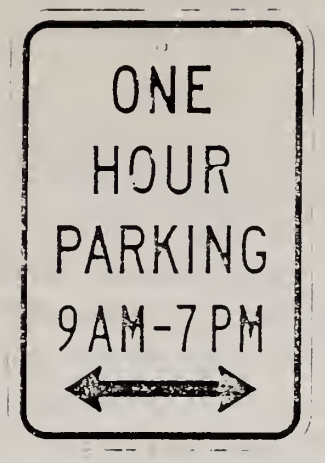
Parking signs and other signs governing the stopping and standing of vehicles cover a very wide variety of regulations and only general specifications can be laid down here. Typical examples are as follows:

NO PARKING ANY TIME (R7-1)
NO PARKING 8:30 AM to 5:30 PM (R7-2)
NO PARKING EXCEPT SUNDAYS AND HOLIDAYS (R7-3)
NO STANDING ANY TIME (R7-4)
ONE HOUR PARKING 9 AM-7 PM (R7-5)
NO PARKING LOADING ZONE (R7-6)
NO PARKING BUS STOP (R7-7, R7-107, R7-107a)

Many other wordings will be found necessary to fit local conditions. To minimize the number of parking signs, blanket regulations that apply to a given district may, if legal, be posted at municipal boundary lines. School area parking signs are treated in Part VII of this Manual.

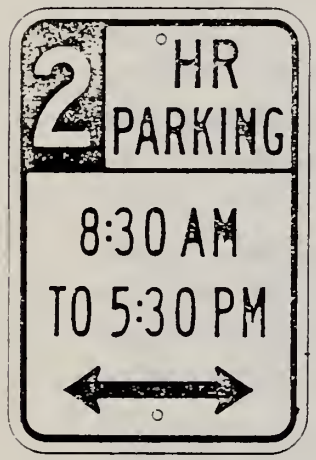
The legend on parking signs shall state whatever regulations apply, but the signs shall conform to the standards of shape, color, location and

R7-1
12" x 18"

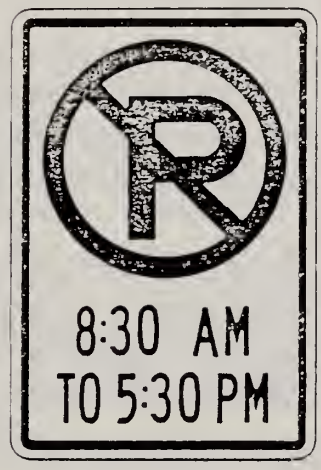


R7-5
12" x 18"

R7-107
12" x 18"

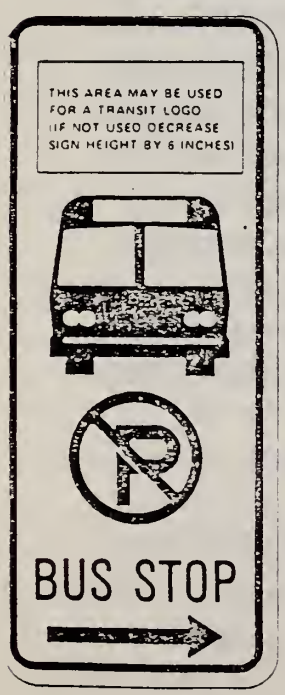


R7-108
12" x 18"



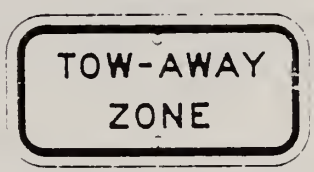
R7-2a
12" x 18"

R7-4
12" x 18"

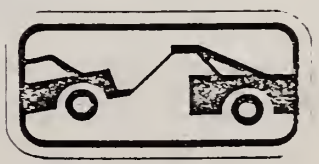


R7-107a
12" x 30"

R7-8
12" x 18"



R7-201
12" x 6"



R7-201a
12" x 6"

use. Generally, parking signs should display such of the following information as is appropriate, from top to bottom of the sign, in the order listed:

1. Restriction or prohibition.
2. Time of day it is applicable, if not at all hours.
3. Days of week applicable, if not every day.

In addition there should be a single-headed arrow pointing in the direction the regulation is in effect, if the sign is at the end of a zone, or a double-headed arrow pointing both ways, if the sign is at an intermediate point in a zone. As an alternate to the arrow, if the signs are posted facing traffic at an angle of 90 degrees to the curb line, there may be included on the sign, or on a separate plate below the sign, such legend as BEGIN, END, HERE TO CORNER, HERE TO ALLEY, THIS SIDE OF SIGN, or BETWEEN SIGNS.

Where parking is prohibited at all times or at specified times, parking signs shall have red letters and border on a white background (Parking Prohibition signs). Where only limited-time parking or parking in a particular manner are permitted, the signs shall have green letters and borders (Parking Restriction signs).

In signs R7-107 and 108, the word NO or the numeral showing the time limit in hours or minutes is presented in a reversed color arrangement in the upper left-hand corner, for emphasis. These two signs should be limited to using the word PARKING rather than STOPPING or STANDING so that the proper size and series of letters need not be sacrificed.

Alternate designs for the R7-107 sign are permissible (R7-107a). Alternate designs may include, on a single panel, a transit logo, an approved bus symbol, a parking prohibition, the words BUS STOP, and an arrow. The preferred bus symbol color is black but other dark colors may be used. Additionally, the transit logo may be shown on the bus face in the appropriate colors in lieu of placing the logo separately. The reverse side of the sign may contain bus routing information.

Where parking is prohibited during certain hours and permitted under a time limit at other periods of the day, two parking signs should ordinarily be used, the red above the green. As an alternative both messages, in different colors may be used on a single plate, with the sign lengthened vertically if necessary.

On urban streets parking signs shall have a standard, and minimum, size of 12 × 18 inches and need not be reflectorized.

At the transition point between two parking zones it may be advantageous to use, instead of two signs, a single sign 24 × 18 inches. This is in effect two standard signs mounted side by side. Such a sign should display a right and a left arrow pointing in the directions that the respective restrictions apply.

Where it is essential that all traffic lanes be kept open for moving traffic, some city authorities make it a practice to tow away illegally parked vehicles. To make the parking regulations more effective and to improve public relations by giving a definite warning, a sign reading TOW-AWAY ZONE (R7-201) may be appended to, or incorporated in, any parking prohibition sign. It should have red legend on a white background. The Tow-Away Zone Symbol sign (R7-201a) may be used in lieu of the R7-201 sign.

Where special parking restrictions are imposed during heavy snowfall, Snow Emergency signs may be erected. The legend will vary according to the regulations, but the signs shall be vertical rectangles, having a white background with the upper part of the plate a red background.

The words NO PARKING may be used as an alternative to the No Parking symbol (shown in sign R8-3a) on signs R7-1, R7-2, R7-3, R7-6, R7-7, and R7-107a. When the symbol sign itself (R8-3a) is used for urban applications, it shall have a minimum and standard size of 12 inches square. The symbol "P" is black, circumscribed in a red circle with a red slash on a white background and black border.

The supplemental educational plaque, NO PARKING, with a red legend and border on a white background, may be used above the symbol.

2B-32 Placement of Urban Parking Signs

When parking signs with arrows are used to indicate the extent of the restricted zones, the signs should be set at an angle of not less than 30 nor more than 45 degrees with the line of traffic flow to be visible to approaching traffic.

Care should be exercised to see that the single arrows point in the proper direction to indicate the regulated zone. Where the zone is unusually long, signs showing a double arrow are desirable at intermediate points within the zone.

If the signs are mounted at an angle of 90 degrees to the curb line, two signs shall be mounted back to back at the transition point between two parking zones, each with the appended plate reading THIS SIDE OF SIGN. At intermediate points within a zone, a single sign without any arrow or appended plate should be used, facing in the direction of approaching traffic. Otherwise the standards of placement should be the same as for signs using directional arrows.

Appendix C

Guidelines for the Design of Parking Lots

Source:

Institute of Transportation Engineers, Transportation and Traffic Engineering Handbook (1982)

in "shopper"-type goods, such as furniture, clothing, and appliances, may require as little as one-fourth that amount.

In recent years, zoning ordinances have not only specified the amount of parking required with various land uses, but also contained provisions for bicycle and motorcycle parking. These provisions in zoning ordinances reflect the concern for adequate off-street parking and storage for these vehicles. The provision for bicycle and motorcycle parking has been handled by some jurisdictions by relating bicycle and motorcycle stalls to the number of automobile parking spaces required. For example, in parking facilities containing more than 40 spaces, the zoning ordinance may require one bicycle parking space or locker for each 20 automobile parking spaces, not to exceed more than 20 bicycle parking spaces in any one lot. For motorcycles, the number of stalls required may be set at 2% of the auto spaces but not to exceed 10 motorcycle stalls on any one lot. Provision of motorcycle stalls generally is not required in lots containing less than 50 spaces.

Design of off-street facilities

Elements of good design

In designing any off-street parking facility, the elements of customer service and convenience and minimum interference with street traffic flow must receive first priority. Basically, drivers like to park their vehicles immediately adjacent to their destinations. The accessibility of the facility, the ease of entering, circulating, parking, unparking, and exiting are important factors in both the location and design of off-street parking facilities.

Good dimensions and ease of internal circulation are more important than trying to get a few additional spaces in a facility. Better sight distance, maneuverability, traffic flow, parking ease, and circulation are the result of a well-organized adequately designed lot or garage.

Major use of the facility

A factor for consideration in designing a parking facility is the use of the facility either in terms of type of parker or type of generator being served. Type of parker can be identified by average duration with either short-term or long-term parkers, or a combination. Design dimensions are often liberalized in facilities used by short-term parkers because of the high turnover rate and the desire to provide easy access, circulation, and parking–unparking.

A parking facility may serve any and all types of parking generators, particularly in a downtown area. However, parking facilities that serve special events, such as sports stadiums, auditoriums, or other similar uses, require special design considerations because of the parker characteristics. Persons attending special events generally arrive over a short time period, and everyone will be leaving upon conclusion of the event. This can place a severe strain on entrance and exit facilities and the internal circulation system. Special consideration must be given to the provision of adequate entrance and exit capacity at such facilities.

Street-capacity problems can also restrict smooth entry and exit at a garage serving a downtown civic center. Conflicts with large volumes of pedestrians is another problem. Airports, shopping centers, office buildings, and department stores all have widely differing loading and unloading characteristics, and the designer must thoroughly evaluate their unique characteristics prior to determining a final design.

Surface lot design

Site characteristics. The characteristics of the proposed site are an important design consideration. Factors such as site dimensions, topography, and profiles affect the design of off-street parking. The relation of the site characteristics to the surrounding street system will affect the location of entry and exit points as well as the internal circulation pattern.

Access points. External factors such as pedestrian traffic controls, turning restrictions, and volumes of traffic on adjacent streets will affect the design of a parking facility—particularly in the location of entry and exit points. It is desirable to avoid locating entry–exit points where vehicles entering or leaving the site would conflict with large numbers of pedestrians. Similarly, street traffic volumes, turning restrictions, and other traffic controls may limit points at which entrances and exits can logically be placed. It is important to investigate these factors before making final decisions on entrances and exits.

Entry and exit points should be located to provide maximum storage space and maximum distance from intersections. Combined entry–exit points should preferably be located at midblock. It is desirable to locate entry and exit points together so that attendants can monitor traffic both in and out from the same vantage point. Where entrances and exits are separated, the exit should preferably be placed in the downstream portion of the block, while the entrance should be placed as far upstream in the block face as possible.

Traffic circulation. The ideal movement into a parking facility is a left-hand turn from a one-way street. This places the driver in a left-hand turn pattern which is desirable on the parking site. The driver position is on the inside of the turn, which allows better visibility and more accurate judgment of the placement of the vehicle. A driver has more difficulty in judging vehicle placement in a right-hand turn.

Vehicle circulation on the site may be either two-way or one-way, depending on site dimensions and the angle of the parking stall. Two-way circulation is generally allowed with 90° stalls, whereas one-way circulation is generally used with stall angles less than 90°. In any event, it is desirable to attempt to minimize traffic conflict points on site so as to minimize the accident potential and congestion during peak hours.

Cross aisles are necessary in large facilities. Generally, no more than 30 spaces should be provided without a cross aisle to get to exits or other parking spaces.

Landscaping. Landscaping of parking facilities is desirable but should be limited to types that will not interfere with the parking function. Care should be taken to use shrub, plant, and tree types that can withstand auto fumes and the concentrated heat arising from a large, paved surface. Landscaping can be an effective means in controlling pedestrian paths. Planting of hedges can serve to funnel pedestrians into desired walk patterns within the site.

Sufficient setback must be provided for all plants so that the front and rear overhang of cars does not destroy them. Extreme care should be exercised in locating shrubbery or other plants near entrances and exits so that sight distances are not restricted. This will require that the growth pattern of the plant be considered so that the small plant of today will not develop into a major sight restriction in future years.

Lighting. Adequate lighting of the parking site is very important. Mounting height and spacing of luminaires should be sufficient to distribute the desired lighting intensity to the entire facility. A normal lighting level is 1.0 to 2.0 footcandles with a uniformity ratio (average illumination divided by the lowest level) not more than 6:1.[1] The luminaire units should be placed so as not to obstruct vehicle movement and parking. Where raised islands are used to separate adjacent parking stalls, the poles can logically be placed on the island. In any event, they should be placed between adjacent stalls and at the ends of the parking rows. Care should be taken to prevent excessive light spillover into adjacent residential areas.

Parking dimensions and layout. The long-term trend in U.S. automobile designs had been toward longer and wider vehicles. This trend was reversed in the 1970's. In the 1978 model year, cars range up to 19.4 ft (5.8 m) in length and 6.66 ft (2.03 m) in width. However, increasing costs of fuel and vehicles has seen the U.S. fleet size growing smaller. Many cars now being manufactured are in the range 14.5 to 16.3 ft (4.4 to 5.0 m) in length and 5.4 to 6.2 ft (1.7 to 1.9 m) in width. Observations indicate that fleet dimensions vary in different parts of the United States. In California, as many as 40% of the vehicles are considered of compact size, whereas in some southern states and in Canada as few as 5% are compacts. It is estimated that as long as 15 years may pass before there is any significant change in fleet size in some parts of the United States.

Typical parking dimensions vary with the angle at which the stall is arranged relative to the aisle (see Table 21-2). Stall widths (measured perpendicular to the vehicle when parked) range from 8.5 to 9.5 ft (2.6 to 2.9 m). In attendant parking facilities, attendants can park standard-size cars in spaces as narrow as 8.0 ft (2.4 m). However, the minimum stall size recommended is 8.5 ft (2.6 m) for self-parking of long-term duration. For higher-turnover self-parking, a stall width of 9.0 ft (2.7 m) is recommended. Stall widths at supermarkets and other similar parking facilities, where large packages are prevalent, should desirably be 9.5 or even 10.0 ft (2.9 to 3.1 m) in width.

Substandard stall and aisle widths prove to be a false economy. Although this permits the marking of more stalls per given length, vehicles tend to encroach upon adjacent stalls so that one or more spaces are unavailable for use. The end result is no gain in actual space usage, but a parking condition surrounded by confusion.

Table 21-2 is based on a stall length of 18.5 ft (5.6 m). The stall length should be sufficient to accommodate the length of most cars expecting to use the space. However, many of the "luxury" U.S. cars exceeded 18.5 ft (5.6 m) in 1978.

Aisle width is a function of the parking angle and stall width. One-way aisles are generally used with angle parking, whereas two-way circulation is generally used with 90° parking.

In designing parking facilities, a common unit of measure is the parking module. A module consists of the width of the aisle, plus the depth of the parking stalls (measured perpendicular to the aisle) on each side of the aisle. In many instances, parking modules are completely separated from each other. Such modules are represented by the wall-to-wall dimensions shown in Table 21-2. Another type of module available for angle parking is the interlocking module. The most common, and preferred, interlocking module is the one that places the bumpers of vehicles in adjacent stalls next to one another. This layout is illustrated in Figure 21.1, together with parking dimensions for various angles of parking. At 45°, a nested interlock is possible where adjacent aisles have one-way movement in the same direction. This places the bumper of one car adjacent to the front fender of another car and is not recommended, as the likelihood of damaged fenders is much greater than with other parking layouts.

TABLE 21-2
Typical Parking Dimensions* (ft)

	Stall Width Parallel to Aisle	Stall Depth to Wall	Stall Depth to Interlock	Aisle† Width	Modules‡ Wall to Wall	Modules‡ Interlock to Interlock
45 deg						
8.5 stall	12.0	19.5	16.5	13	52	46
9.0 stall	12.7	19.5	16.5	12	51	45
9.5 stall	13.4	19.5	16.5	11	50	44
60 deg						
8.5 stall	9.8	20.5	18.5	18	59	55
9.0 stall	10.4	20.5	18.5	16	57	53
9.5 stall	11.0	20.5	18.5	15	56	52
75 deg						
8.5 stall	8.3	20.0	19.0	25	65	63
9.0 stall	9.3	20.0	19.0	23	63	61
9.5 stall	9.8	20.0	19.0	22	62	60
90 deg§						
8.5 stall	8.5	18.5	18.5	28	65	65
9.0 stall	9.0	18.5	18.5	26	63	63
9.5 stall	9.5	18.5	18.5	25	62	62

*These dimensions are for 18.5-ft-length stalls, measured parallel to the vehicle, and are based on results of a special study to evaluate the effects of varied aisle and stall width for the different parking angles shown. The study was conducted in December 1970 by the Federal Highway Administration and Paul C. Box and Associates. Conversion factor: 1 ft = 0.305 m.

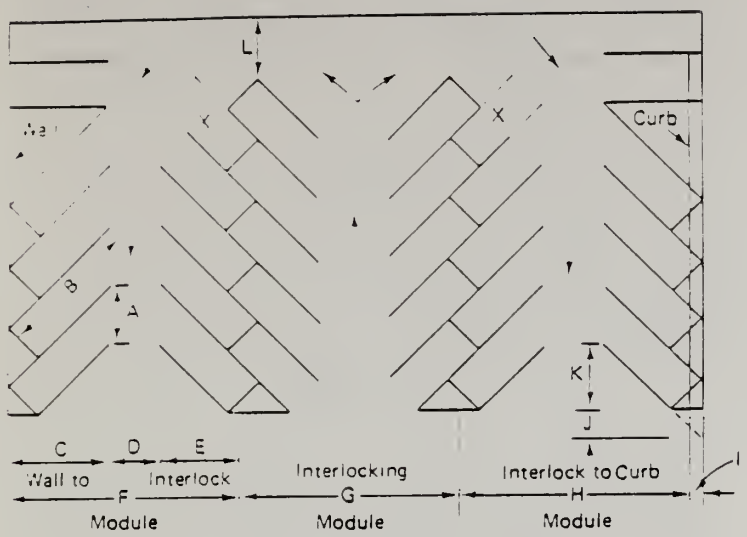
†Measured between ends of stall lines.

‡Rounded to nearest foot.

§For back-in parking, aisle width may be reduced 4.0 ft.

SOURCE: *Parking Principles*, Special Report No. 125, Highway Research Board, Washington, D.C., 1971, p. 101.

[1] *Parking Principles*, Special Report No. 125, Highway Research Board, Washington, D.C., 1971, p. 107.



X = Stall not accessible in certain layouts

Parking layout dimension (in ft) for 9 ft × 18.5 ft stalls at various angles

Dimension	On diagram	Angle 45°	60°	75°	90°
Stall width, parallel to aisle	A	12.7	10.4	9.3	9.0
Stall length of line	B	27.5	23.7	20.9	18.5
Stall depth to wall	C	19.5	20.5	20.0	18.5
Aisle width between stall lines	D	12.0	16.0	23.0	26.0
Stall depth, interlock	E	16.5	18.5	19.0	18.5
Module, wall to interlock	F	48.0	55.0	62.0	63.0
Module, interlocking	G	45.0	53.0	61.0	63.0
Module, interlock to curb face	H	46.0	52.5	59.5	60.5
Bumper overhang (typical)	I	2.0	2.3	2.5	2.5
Offset	J	6.4	2.6	0.6	0.0
Setback	K	13.1	9.3	4.8	0.0
Cross aisle, one-way	L	14.0	14.0	14.0	14.0
Cross aisle, two-way	–	24.0	24.0	24.0	24.0

Figure 21.1. Stall layout elements. SOURCE: Based on *Parking Principles*, Special Report No. 125, Highway Research Board, Washington, D.C., 1971, p. 99.

TABLE 21-3
Parking Dimensions for Import-Size Vehicles (15-ft Length)*

Parking Angle (deg)	Stall Width	Aisle Length Stall	Depth of Stalls at Right Angle to Aisle	Aisle Width	Wall-to-Wall Module
45	7.5	10.5	16.0	11.0	43.0
60	7.5	8.7	16.7	14.0	47.4
75	7.5	7.8	16.3	17.4	50.0
90	7.5	7.5	15.0	20.0	50.0

1 ft. = 0.305m

*These measurements are *inadequate* for average American compacts. Each stall depth should be increased about 1 ft (2 ft total for the module) to accommodate the usual range of compact sizes.

SOURCE: *Parking Principles*, Special Report No. 125, Highway Research Board, Washington, D.C., 1971, p. 102.

TABLE 21-4
Parking Standards, Europe

	Stall Width [ft-in. (m)]		Stall Length [ft-in. (m)]	Aisle Width [ft-in. (m)]	Bay Width [ft-in. (m)]
General	7-10 to 8-2 (2.4–2.5)		15-7 to 16-5 (4.75–5.0)	18 to 19-6 (5.5–6.0)	50-10 to 52-6 (15.5–16.0)
Belgium	7-10 to 8-2 (2.4–2.5)		16-5 (5.0)		52-6 (16.0) (90°) 50-10 (15.0) (60°)
Paris	7-10 (2.4)	(90°)	16-5 (5.0)		
	7-6 (2.3)	(45°)	16-5 (5.0)		
	7-3 (2.2)	(30°)	16-5 (5.0)		
U.K.	7-10 to 8-2 (2.4–2.5)		15-7 to 16-5 (4.75–5.0)		50-10 to 52-6 (15.5–16.0)
Madrid	7-10 (2.4)		16-5 (5.0)		50-10
	7-3 (2.2)*		13-1 (4.0)*		(15.5)
Barcelona	7-10 (2.4)		15-7 (4.75)		50-10 (15.5)
Germany	7-6 to 7-10 (2.3–2.4)		16-5 to 18-1 (5.0–5.5)		

*25% spaces, for Spanish subcompacts, may be this size.

SOURCE: JOHN GLANVILLE, *Provision, Location and Design of Parking Facilities in Europe*, International Road Federation, Washington, D.C. 1970; OTTO STILL, *The Construction of Parking Facilities*, Bauverlag GMBH, Wiesbaden-Berlin, 1968.

Recommended parking dimensions for imported cars—15 ft (4.6 m) in length—differ from recommendations for standard U.S. cars (see Table 21-3). Table 21-4 summarizes European parking dimension standards. Stall lengths and widths are recommended at 15 ft (4.6 m) and 7.5 ft (2.3 m), respectively. If a number of these smaller-size spaces are to be included in a facility, they should be placed together in a prime location to encourage their use. If these spaces are not convenient, small-car drivers will park elsewhere in standard-size spaces. Because of difficulties in predicting the amount of usage and in controlling the spaces, most U.S. parking facilities are being designed with all spaces of sufficient size for standard American cars. However, on the west coast of the United States, many facilities are being designed to accommodate a percentage of compact cars.

In the actual layout of the parking stalls and circulation aisles, it is always desirable to have a row of parking on each side of the aisle. This gives the most efficient design. In addition, the greatest efficiency can generally be obtained by placing aisles and rows of parking parallel to the long dimension of the site. Greatest parking efficiency can usually be aided by placing a row of parking completely around the perimeter of the site. With adequate site dimensions this places parking stalls on both sides of the aisle, including end aisles.

When pedestrian walks are used in parking facilities, they should direct pedestrians toward the major parking generators. Raised sidewalks can be used in larger facilities between rows of cars to aid pedestrian flow. However, many pedestrians will still use the aisles and the need for raised pedestrian walks is debatable.

Relative efficiency factors. Relative efficiency factors can be calculated for various parking angles and stall widths (see Table 21-5). The figures represent the number of square feet per stall plus one-half of the aisle width for a distance equal to the stall width measured parallel to the aisle. Those dimensions were obtained from Table 21-2. Stalls arranged at 90° to the aisles provide the most efficient design, and the efficiency decreases as the parking angle decreases

TABLE 21-5
Relative Efficiency Factors*

Parking Angle (deg)	Width of Stall (ft)		
	8.5	9.0	9.5
45	308	324	340
60	288	296	310
75	286	295	308
90	276	284	295

*Square feet per stall area plus one-half aisle area; does not include end aisle circulation areas or unusable area at ends of parallel parking rows.

SOURCE: Based on data included in Table 21-2.

Handicapped parking. Most jurisdictions require that a certain number of parking spaces be set aside for parking for the handicapped. Most requirements are that approximately 4% of the total number of spaces within a facility be set aside for handicapped, with a maximum of 9 or 10 in the entire facility regardless of size. In small facilities of 25 spaces or less, the number required is approximately one for each such facility.

The handicapped stall layout is shown in Figure 21.2. In addition to the stall layout, the spaces should be marked with a sign at the face of the stall. Stencilling or painting of the handicap symbol on the pavement is not recommended since it is difficult to see while driving and can be obscured by snow and other obstructions. In general, the handicap spaces should be located immediately adjacent to the exit of the lot or garage.

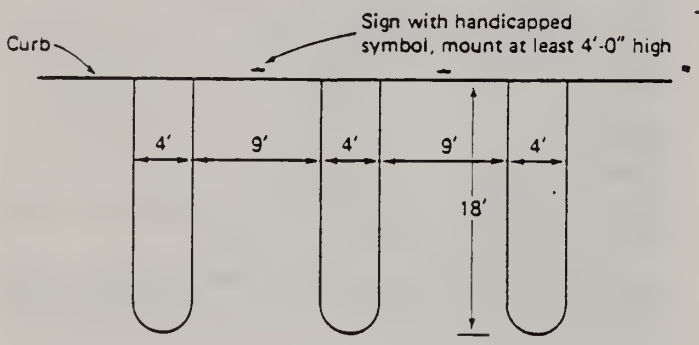


Figure 21.2. Handicapped parking stall dimensions. SOURCE: James Madison Hunnicutt & Associates.

Drainage. Adequate slope should be provided to surface lots to minimize the possibility of low or flat spots. The ponding of water in a lot is undesirable for both vehicle and pedestrian movement. This is particularly true in cold climates, where freezing may lead to icy spots. Recommended minimum grades are 1.0% for asphalt surfaces and 0.5% for portland cement concrete surfaces.[2]

Surface vs. structure parking. Development costs at 1979 prices for surface parking lots normally are $2 to $3 per square foot exclusive of land, with an average figure approximating $2.50 per square foot. This includes all improvement costs, such as grading, paving, lighting, drainage, signing, and marking. Land cost is often the factor that determines economic viability of surface parking. As land costs increase, it often becomes economically justified to expand parking vertically in a parking structure, rather than expanding horizontally by the acquisition of additional land for surface parking.

Parking garage construction costs at 1979 prices vary from approximately $3000 per car space to as high as $6000, with an average being approximately $4000 to $4500. These are construction costs without land, and the variation is caused by topography, expensive vs. economical architectural treatment, sophistication of revenue control devices, foundations, and other factors. If land costs are not included, the cost of a parking structure is approximately four times the cost of an equivalent parking space in a surface lot. On the other hand, if the land cost is included, the figures can change rapidly.

As an example, a 340-ft^2 per car lot would cost $850 per car space for grading, paving, and lighting. If land is calculated at $15 per square foot, this adds $5100 per car space for a $5950 total cost. On the other hand, if a five-level garage is constructed and the land cost is prorated over the five floors, the same amount of land costs would only be $1020 per car space. When added to the $4000 per car space in construction costs, the total cost for a parking garage space would be slightly above $5000, and it would be less expensive per car space to build a parking garage than a surface lot.

Many other factors must be considered in making the decision between surface and structured parking. In the case of private developers, these include demand characteristics, taxes, and financing. The primary considerations for all parking must be the walking distance of the patrons, maintenance, security, operation, and the availability of land and traffic access.

Garage design

Site characteristics. Many of the factors that affect the location and design of surface lots also affect the design of parking garages. Site characteristics such as size, shape, and topography are important factors in garage design. The topography of a site may allow direct entry to more than one level of the garage. This will affect entry and exit locations as well as the interfloor travel system within the structure.

Access points. The location of entry and exit points is even more critical in garage design than in surface lot design, because of the increased number of spaces available in structured parking. Street capacities, location of traffic controls, and other external factors must be carefully analyzed to assure a design that is compatible with the surrounding street system.

Major use of the facility. As in surface lots, the dominant type of use, whether by short-term or long-term parkers, or whether the facility will serve special events, will influence the design. Where vehicles enter and exit in short

[2] *Parking Principles*, Special Report No. 125, Highway Research Board, Washington, D.C., 1971, p. 107.